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SUPERCHARGING PRESSURE CONTROL DEVICE FOR INTERNAL COMBUSTION ENGINE
[NAINENKIKAN NO KAKYUATSU SEIGYOSOCHI]

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(54) Title of the Invention

SUPERCHARGING PRESSURE CONTROL DEVICE FOR INTERNAL COMBUSTION ENGINE

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[Claims]

[Claim 1] A supercharging pressure control device for an internal combustion engine equipped with a turbo supercharger that performs intake supercharging by a compressor rotating along with a turbine driven by the exhaust gas flow, characterized in that post injection of the fuel after the main injection is performed when the supercharging pressure of said turbo supercharger is raised.

[Claim 2] A supercharging pressure control device for internal combustion engine characterized in that said main injection and post injection are performed by an injector that turns ON-OFF injection of the fuel by an electromagnetic valve.

[Claim 3] The supercharging pressure control device for an internal combustion engine as described in Claim 1 or 2, characterized in the following facts: The active state of an exhaust gas purification means disposed in the exhaust passage on the downstream of the turbine of said turbo supercharger to purify the inflow of the exhaust gas component is judged; if said exhaust gas purification means is inactive, said turbine is

bypassed to increase the bypass flow rate of the exhaust gas fed into said exhaust gas purification means; if said exhaust gas purification means is active, a bypass flow rate control is performed to reduce said bypass flow rate, and said post injection is performed when said bypass flow rate is switched from a high level to a low level.

[Claim 4] The supercharging pressure control device for an internal combustion engine as described in Claim 3, characterized in that the opening of an exhaust gas bypass valve installed on the bypass passage that bypasses said turbine is controlled to control said bypass flow rate.

[Claim 5] The supercharging pressure control device for an internal combustion engine as described in any of Claims 1-4, characterized in that said supercharging pressure or intake air amount is detected, and if the detected value is smaller than a prescribed value, said post injection is performed.

[Claim 6] The supercharging pressure control device for an internal combustion engine as described in Claim 5, characterized in that the post injection amount is set higher as said supercharging pressure or intake air amount is further away from the targeted value on the smaller side.

[Claim 7] The supercharging pressure control device for an internal combustion engine as described in any of Claims 3-6, characterized in the following facts:

EGR control that refluxes part of the exhaust gas to the intake gas and/or throttle control of the intake passage is used to control the excessive air rate;

if said exhaust gas purification means is inactive, the excessive air rate is kept low; when said post injection is performed after the exhaust gas purification means is activated, the excessive air rate is controlled to increase as the post injection amount increases.

[Claim 8] The supercharging pressure control device for an internal combustion engine as described in any of Claims 3-7, characterized in the following facts: When there is an acceleration request based on the acceleration operation performed by the driver, even if said exhaust gas purification means is inactive, the bypass flow rate of said exhaust gas is reduced, and the post injection is performed during the period when said supercharging pressure or intake air amount is smaller than the prescribed value.

[Claim 9] The supercharging pressure control device for an internal combustion engine as described in Claim 8, characterized in that the bypass flow rate of said exhaust gas is reduced as the acceleration request is increased.

[Claim 10] The supercharging pressure control device for an internal combustion engine as described in Claim 8 or 9,

characterized in that said prescribed value is set bigger as the acceleration request is increased.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention] The present invention relates to control of supercharging pressure in an internal combustion engine equipped with a turbo supercharger.

[0002] A diesel engine for vehicle is usually equipped with a supercharger used for output improvement. It can also realize installation of exhaust gas purification means, such as a catalyst used for purifying HC, CO, NOx or a trap device used for trapping PM (particles in the exhaust gas). According to a technology disclosed in Japanese Kokai Patent Application No. Hei 5[1993]-44448, when an exhaust gas purification catalyst provided on the downstream of the turbine of a turbo supercharger is inactive, the turbine is bypassed, and the exhaust gas that is restrained from being cooled off by the turbine is fed to the catalyst. After the catalyst is activated, bypass of the exhaust gas is stopped, and supercharging is performed.

[0003]

[Problems to Be Solved by the Invention] However, since the rotation speed of the supercharger is low during bypass of the exhaust gas, if there is an acceleration request right after the catalyst is activated and bypass of the exhaust gas is stopped,

the response delay (delay in raising the supercharging pressure) of the supercharger is increased. The amount of the intake air is not increased as the amount of the injected fuel is increased. The air-fuel ratio drops. As a result, smoke is increased, and the operability becomes poor.

[0004] The objective of the present invention is to solve the aforementioned problem by restraining the delay in raising the supercharging pressure and well maintaining the exhaust gas purification performance.

[0005]

[Means for Solving the Problem] Therefore, the invention described in Claim 1 provides a supercharging pressure control device for internal combustion engine equipped with a turbo supercharger that performs intake supercharging by a compressor rotating along with a turbine driven by the exhaust gas flow. This supercharging pressure control device is characterized in that post injection of the fuel after the main injection is performed when the supercharging pressure of said turbo supercharger is raised.

[0006] According to the invention described in Claim 1, the temperature of the exhaust gas can be responsively raised to a sufficiently high level by the post injection, and the enthalpy of the exhaust gas at the turbine entrance can be quickly increased. Therefore, the rotation speed of the turbine can be

quickly increased, and the supercharging pressure can be quickly raised by the compressor rotating along with the turbine.

[0007] In this way, during acceleration when the amount of the fuel is increased or when the supercharging pressure drops below a prescribed level, the amount of the intake air can be increased responsively to prevent increase of the smoke and realize good operability. The invention described in Claim 2 is characterized in that said main injection and post injection are performed by an injector that turns ON-OFF injection of the fuel by an electromagnetic valve.

[0008] According to the invention described in Claim 2,

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the main injection and post injection can be accurately controlled by turning ON-OFF the fuel injection by the electromagnetic valve. The invention described in Claim 3 is characterized in the following facts: The active state of an exhaust gas purification means disposed in the exhaust passage on the downstream of the turbine of said turbo supercharger to purify the inflow of the exhaust gas component is judged; if said exhaust gas purification means is inactive, said turbine is bypassed to increase the bypass flow rate of the exhaust gas fed into said exhaust gas purification means; if said exhaust gas purification means is active, a bypass flow rate control is performed to reduce said bypass flow rate, and said post

injection is performed when said bypass flow rate is switched from a high level to a low level.

[0009] According to the invention described in Claim 3, when the exhaust gas purification means [NOx trap catalyst, oxidation catalyst, DPF (diesel particulate filter) or the like] becomes inactive at low temperature, the bypass flow rate of the exhaust gas is increased. In this way, cooling of the exhaust gas by the heat dissipated to the turbine can be restrained, and the temperature of the exhaust gas can be raised so that activation of the exhaust gas purification means can be accelerated.

[0010] When the exhaust gas purification means is activated, the aforementioned bypass flow rate is switched from a high level to a low level (including 0) to raise the supercharging pressure of the aforementioned turbo supercharger. At that time, the aforementioned post injection is performed to prevent increase of the smoke and quickly raise the supercharging pressure. The invention described in Claim 4 is characterized in that the opening of an exhaust gas bypass valve installed on the bypass passage that bypasses said turbine is controlled to control said bypass flow rate.

[0011] According to the invention described in Claim 4, when the opening of exhaust gas bypass valve is reduced, the aforementioned bypass flow rate is reduced. When the opening of the exhaust gas bypass valve is increased, the aforementioned

bypass flow rate can be increased. The post injection is performed when the exhaust gas bypass valve is switched from a big opening to a small opening to increase the bypass flow rate. The post injection is, however, continued when the supercharging pressure is still low right after the opening of the exhaust gas bypass valve is reduced. Alternatively, the post injection is performed before the exhaust gas bypass valve is switched from a big opening to a small opening so that the supercharging pressure has already reached a high level when the switching ends.

[0012] The invention described in Claim 5 is characterized in that said supercharging pressure or intake air amount is detected, and if the detected value is smaller than a prescribed value, said post injection is performed. According to the invention described in Claim 5, since the post injection is performed only during the period when the supercharging pressure or the intake air amount is below a prescribed level, the period of performing the post injection with high fuel cost can be minimized. Therefore, both the effect of reducing the smoke and improving the operability and good fuel cost effectiveness can be realized.

[0013] The invention described in Claim 6 is characterized in that the post injection amount is set higher as said supercharging pressure or intake air amount decreases with respect to the targeted value. According to the invention described in Claim 6, since the post injection amount is set

bigger as the supercharging pressure or intake air amount is further away from the targeted value on the smaller side, if the delay in the supercharging pressure is big in the initial acceleration period, a bigger post injection amount will be set. When the supercharging pressure rises, the post injection amount can be gradually reduced. Therefore, the fuel cost increase caused by the post injection can be minimized, and the effect of reducing the smoke and improving the operability can also be realized.

[0014] The invention described in Claim 7 is characterized in the following facts: EGR control that refluxes part of the exhaust gas to the intake gas and/or throttle control of the intake passage is used to control the excessive air rate; if said exhaust gas purification means is inactive, the excessive air rate is kept low; when said post injection is performed after the exhaust gas purification means is activated, the excessive air rate is controlled to increase as the post injection amount increases.

[0015] According to the invention described in Claim 7, when the exhaust gas purification means is inactive at a low temperature, the temperature of the exhaust gas can be raised by keeping the excessive air rate low without performing the post injection. In combination with the heating effect by the bypass of the exhaust gas, the exhaust gas purification means can be quickly heated up

and activated. Also, when the post injection is performed, the excessive air rate is kept high so that deterioration of HC, CO can be restrained during the post injection.

[0016] The invention described in Claim 8 is characterized in the following facts: when there is an acceleration request based on the acceleration operation performed by the driver, even if said exhaust gas purification means is inactive, the bypass flow rate of said exhaust gas is reduced, and the post injection is performed during the period when said supercharging pressure or intake air amount is smaller than the prescribed value.

[0017] According to the invention described in Claim 8, when there is an acceleration request based on the acceleration operation performed by the driver, even if the exhaust gas purification means is inactive, the bypass flow rate of the exhaust gas is reduced (including 0), and the post injection is performed until the supercharging pressure or intake air amount reaches the prescribed level. Therefore, the acceleration request can be satisfied with higher priority.

[0018] The invention described in Claim 9 is characterized in that the bypass flow rate of said exhaust gas is reduced as the acceleration request is increased. According to the invention described in Claim 9, the bypass flow rate of the exhaust gas is reduced as the acceleration request is increased. In this way,

the increase of the supercharging pressure can be accelerated to realize the requested acceleration.

[0019] The invention described in Claim 10 is characterized in that said prescribed value is set bigger as the acceleration request is increased. According to the invention described in Claim 10, the aforementioned prescribed value is set higher as the acceleration request is increased. In this way, the period of performing the post injection can be extended to maintain the rise of the supercharging pressure so that the requested acceleration can be realized.

[0020]

[Embodiment of the Invention] In the following, the embodiment of the present invention will be described based on the figures. In Figure 1, the fuel injection system of engine (diesel engine or other internal combustion engine) 1 adopts a common rail type fuel injection system comprised of common rail 2,

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injector 3 that turns ON-OFF injection of the fuel by an electromagnetic valve, and a supply pump not shown in the figure.

[0021] The turbine 5T of turbo supercharger 5 is provide don the downstream of exhaust manifold 4. A compressor 5C is installed coaxially with said turbine 5T. After the intake gas is compressed and pressurized by compressor 5C, it is sucked into the cylinder of engine 1 through intake passage 6 via collector 7.

An intake throttle valve 8 used for throttling the intake gas amount is installed on intake passage 6. Also, supercharging pressure sensor 9 used for detecting the supercharging pressure (intake pressure) is installed in collector 7.

[0022] Said exhaust manifold 4 and intake passage 6 are connected to each other by EGR passage 10. The EGR gas amount is controlled by the opening of EGR valve 11 installed on said EGR passage 10. Catalyst (exhaust gas purification means) 13 is installed in exhaust passage 12 on the downstream of turbine 5T. Catalyst temperature sensor 14 is used to detect the temperature of catalyst 13. The exhaust manifold 4 on the upstream side and the exhaust passage 12 on the downstream side are connected by bypass passage 15. The opening area of bypass passage 15 is controlled by exhaust gas bypass valve 16.

[0023] The engine rotation speed signal detected by rotation speed sensor 31, the acceleration opening signal detected by acceleration opening sensor 32, the catalyst temperature signal detected b catalyst temperature sensor 14, and the supercharging pressure signal detected by supercharging pressure sensor 9 are input into engine control unit 17. Based on these signals, the operation instruction signals are output to injector 3, intake throttle valve 8, EGR valve 11, and exhaust gas bypass valve 16.

[0024] In the following, the control of this embodiment will be described based on the flow chart shown in Figure 2. In step 1,

engine rotation speed Ne, acceleration opening Acc, catalyst temperature Tcat, and supercharging pressure Boost are read from the aforementioned sensors. In step 2, it is determined whether catalyst temperature Tcat is lower than a prescribed value T0. Said prescribed value T0 is a value (for example, 200°C) corresponding to the activation temperature of the catalyst (generally speaking, the temperature at which the efficiency for purifying the exhaust gas component becomes 50%).

[0025] If the catalyst temperature Tcat is lower than prescribed value T0, the process goes to step 3 to determine whether acceleration opening Acc is smaller than a prescribed value A0. In other words, it is determined whether there is acceleration request from the driver. In this case, it is also possible to determine whether the variation ΔAcc in the acceleration opening is less than a prescribed value ΔA0. If acceleration opening Acc is smaller than the prescribed value A0, that is, if there is no acceleration request, the process goes to step 4 and thereafter to carry out the control for accelerating warming up of catalyst 13.

[0026] In step 4, exhaust gas bypass valve 16 is fully opened to increase the bypass amount of turbine 5T. In this way, heat dissipation of the exhaust gas to turbine 5T can be restrained, and the temperature drop of the exhaust gas fed to the catalyst

can be suppressed. In step 5, post injection amount Qp=0. The long-time post injection is inhibited when warming up the catalyst to restrain increase of the fuel cost and deterioration of the exhaust performance.

[0027] In step, the targeted EGR rate is set as follows. First, the basic targeted EGR rate MEGR0 is set based on engine rotation speed Ne and acceleration opening Acc from the table shown in Figure 4. Then, the first correction coefficient α for the EGR rate is derived based on catalyst temperature Tcat from the table shown in Figure 4. As shown in the figure, the first correction coefficient α for the EGR rate is set to a bigger value as catalyst temperature Tcat drops. Finally, the product of the basic targeted EGR rate MEGR0 and the first correction coefficient α for the EGR rate is used as the targeted EGR rate MEGR.

[0028] When the EGR rate is increased under the condition of the same supercharging pressure, the amount of the air sucked into the cylinder is reduced. The proportion with the fuel injection amount, that is, the excessive air rate is decreased. Since the targeted EGR rate is corrected to increase as catalyst temperature Tcat drops as a result of the aforementioned operation, the excessive air rate decreases. When the excessive air rate is lowered, the amount of the low-temperature air (fresh

air) in the intake gas is reduced. Since the amount of the high-temperature EGR gas is increased, the temperature of the intake gas rises, and the temperature of the exhaust gas can be raised. Therefore, the catalyst heating effect can be improved.

[0029] If it is found in step 2 that catalyst temperature Tcat is equal to or higher than the prescribed value TO meaning that catalyst is active or if it is found in step 3 that acceleration opening Acc is equal to or bigger than the prescribed value A0 meaning that there is an acceleration request, the process goes to step 7 to perform supercharging with higher priority to guarantee the acceleration performance. Said exhaust gas bypass valve 16 is completely closed to inhibit bypass to turbine 5T. When the process goes from step 3 to step 7, the opening of exhaust gas bypass valve 16 can also be set corresponding to the acceleration request. In other words, instead of completely closing the valve, it is also possible to gradually close the valve to reduce the bypassing proportion as Acc-A0 (or ΔAcc-ΔA0) is increased.

[0030] In step 8, it is determined whether the detected supercharging pressure Boost is smaller than a prescribed value B0. If it is smaller than the prescribed value B0, the post injection amount Qp is set based on the map shown in Figure 5 in step 9. In other words, as the supercharging pressure Boost drops, the post injection amount Qp is increased to sufficiently

raise the temperature of the exhaust gas. In this way, the enthalpy at the turbine entrance is increased, and the exhaust energy recovery efficiency by the turbine is increased. The intake gas compression work performed by the compressor is increased, and the supercharging pressure can be quickly raised. In this case, if the process advances from step 3, the prescribed value B0 can also be set corresponding to the operation condition (acceleration request). That is, the prescribed value B0 can also be set higher as Acc-A0 (or ΔAcc-ΔA0) increases. The judgment can also be made based on the intake air amount instead of the supercharging pressure. That is, when intake air amount Qac < targeted value Qac0,

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the process goes to step 9.

[0031] In step 10, the targeted EGR rate is set as follows. First, the basic targeted EGR rate MEGR0 is set based on engine rotation speed Ne and acceleration opening Acc from the map shown in Figure 3 in the same way as in step 6. Then, the second correction coefficient β for EGR rate is derived based on post injection amount Qp from the table shown in Figure 6. The second correction coefficient β for EGR rate is set to a smaller value as the post injection amount Qp increases as shown in the figure. Finally, the product of basic targeted EGR rate MEGR0 and the

second correction coefficient β for EGR rate is sued as the targeted EGR rate MEGR. In this way, since the targeted EGR rate MEGR is lowered as post injection amount Qp increases, a high excessive air rate can be set. In other words, the targeted EGR rate is set such that fire caused by the post injected fuel can be prevented by the excessive EGR and the heating effect by EGR can be realized.

[0032] If it is found in step 8 that supercharging pressure Boost is equal to or higher than the prescribed value B0, the process goes to step 11, and post injection amount becomes Qp=0. Then, in step 12, the basic targeted EGR rate MEGR0 is read based on engine rotation speed Ne and acceleration opening Acc from the map shown in Figure 3 and is used as the targeted EGR rate MEGR. That is, the targeted EGR rate is corrected to decrease by using the post injection amount Qp. In other words, the post injection can sufficiently raise the temperature of the exhaust gas in a responsive manner. However, in order to avoid increase of the fuel cost and deterioration of HC, CO, post injection is only performed for a short period of time when the supercharging pressure is low. After the temperature of the exhaust gas is raised by a certain degree, it switches to the heating realized by EGR. The sufficiently high heating effect can be maintained so that the supercharging pressure can quickly reach the targeted level.

[0033] Finally, in step 13, the opening signals of intake throttle valve 10 and EGR value 14 are calculated and output based on the targeted EGR rate set in steps 6, 10, 12. In the aforementioned embodiment, a case in which only EGR control is performed when controlling the excessive air rate has been described. However, it is also possible to use intake throttle valve 10 in combination for the control. That is, When intake throttle valve 10 is controlled to directly reduce the air amount, the excessive air rate can be well reduced in a more responsive way than the case that only depends on the EGR control.

[0034] Also, in this embodiment, the post injection is performed after exhaust gas bypass valve 16 is closed. However, the post injection can also be started before or at the same time when exhaust gas bypass valve 16 is closed.

[Brief Description of the Figures]

[Figure 1] Figure 1 is a diagram illustrating the system configuration of the embodiment of the present invention.

[Figure 2] Figure 2 is a flow chart illustrating the control routine in the aforementioned embodiment.

[Figure 3] Figure 3 shows the map for driving the basic targeted EGR rate used in the aforementioned embodiment.

[Figure 4] Figure 4 shows the map used for setting the first correction coefficient α for the EGR rate.

[Figure 5] Figure 5 shows the table used for setting the post injection amount Qp.

[Figure 6] Figure 6 shows the map used for setting the second correction coefficient β for the EGR rate.

[Description of the Symbols]

1 Engine

3 Injector

5 Turbo Supercharger

5T Turbine

8 Intake Throttle Valve

9 Supercharging Pressure Sensor

10 EGR Passage

11 EGR Valve

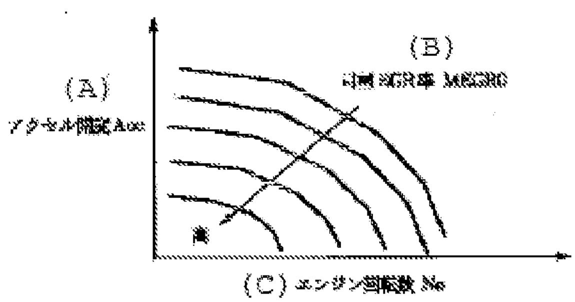
13 Catalyst

14 Catalyst Temperature Sensor

15 Bypass Passage

16 Exhaust Gas Bypass Valve

[Figure 3]

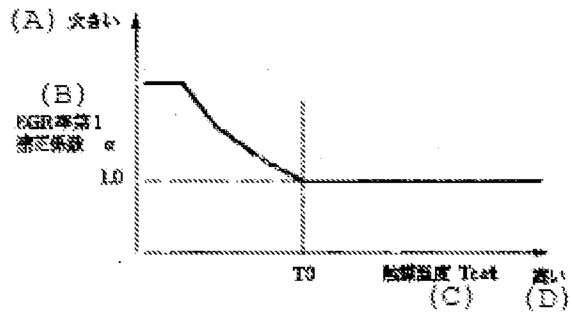


(A): Acceleration Opening Acc

(B): Targeted EGR Rate MEGR0

(C): Engine Rotation Speed Ne

[Figure 4]



(A): Bigger

(B): First Correction Coefficient α for EGR Rate

(C): Catalyst Temperature Tcat

(D): Higher

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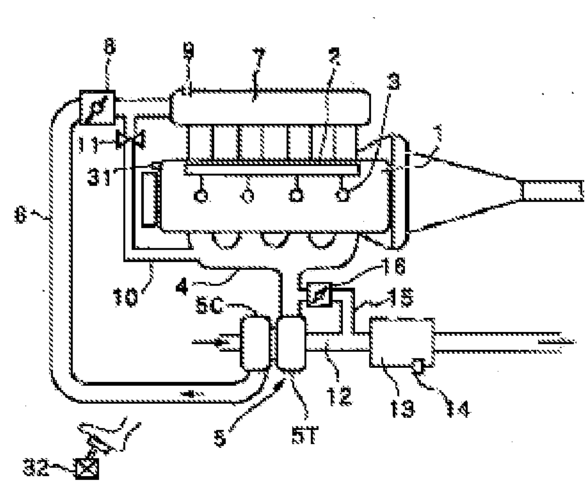
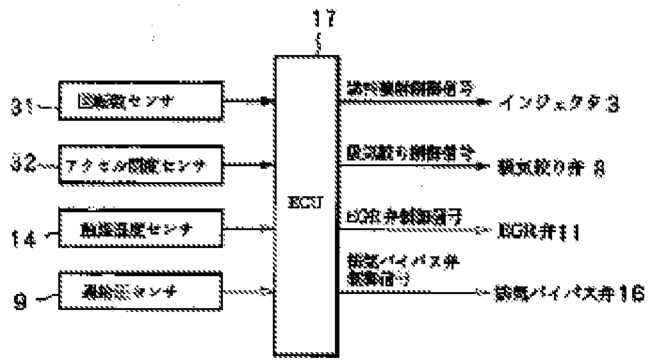
[Figure 1]





31: Rotation Speed Sensor

32: Acceleration Opening Sensor

14: Catalyst Temperature Sensor

9: Supercharging Pressure Sensor

17: ECU

[Middle and Right, Top to Bottom]:

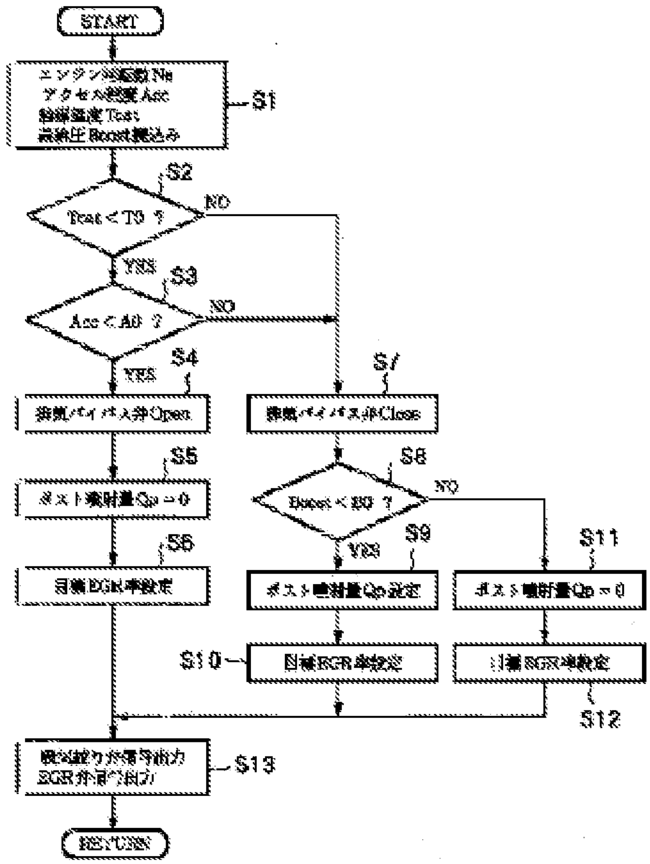
Fuel Injection Control Signal → Injector 3

Intake Throttle Control Signal → Intake Throttle Valve 8

EGR Valve Control Signal → EGR Valve 11

Exhaust Gas Bypass Valve Control Signal → Exhaust Gas Bypass Valve 16

[Figure 2]



S1: Read in the engine rotation speed Ne, acceleration opening Acc, catalyst temperature Tcat, and supercharging pressure Boost

S4: Open the exhaust gas bypass valve

S5: Post injection amount Qp=0

S6: Set the targeted EGR rate

S7: Close the exhaust gas bypass valve

S9: Set post injection amount Qp

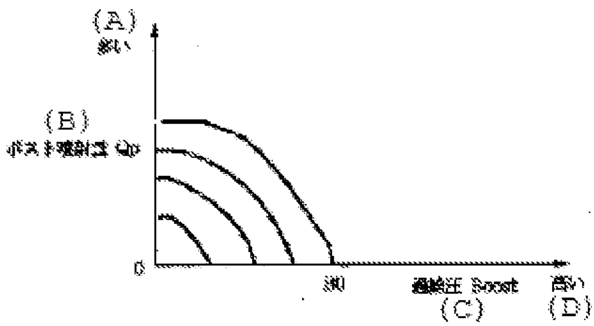
S10: Set the targeted EGR rate

S11: Post injection amount Qp=0

S12: Set the targeted EGR rate

S13: Output the intake throttle valve signal, output the EGR valve signal

[Figure 5]



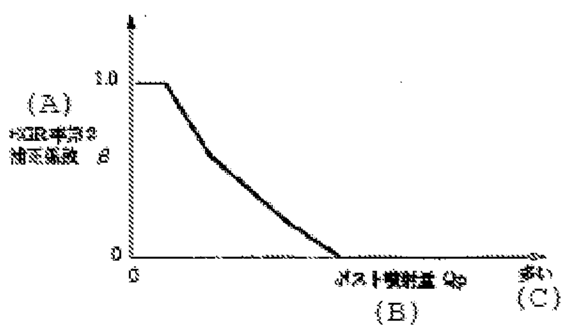
(A): More

(B): Post Injection Amount Qp

(C): Supercharging Pressure Boost

(D): Higher

[Figure 6]



(A): Second Correction Coefficient β for EGR Rate

(B): Post Injection Amount Qp

(C): More